MECHANICAL BEHAVIOUR OF TIMBER REINFORCED WITH FRP UNDER COMPRESSION

P. de la Rosa García [1], A. Cobo Escamilla [2], M.N. González García [1], P. Yanes González [3]

(1) Dpto. de Construcciones Arquitectónicas y su Control. ETSEM. UPM
(2) Dpto. de Tecnología de la Edificación. ETSEM. UPM
(3) Dpto. Ingeniería de la Construcción, E.U.A.T.- ULL

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1. Introduction – This experimental work analyses the behaviour of sawn timber pieces strengthened with fibre-reinforced polymers tested under compression parallel to the grain. The specimen dimensions are 158x158mm cross-section by 300mm length. The aim of this study is to compare both the strength and strain of the specimens reinforced and non-reinforced. Basalt and carbon fibres have been applied and compared.

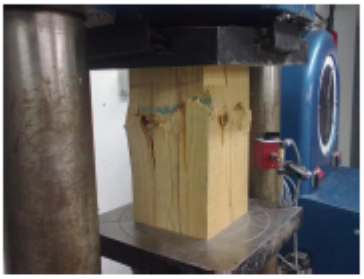

Fig. 1: Compression test of a non-reinforced specimen.

Wood is natural material traditionally used in construction industry performing different functions like structural elements, claddings, partitions, etc. Timber has excellent mechanical properties in relation with its weight. Its compression strength varies significantly depending on the direction of the fibres. The compression strength perpendicular to the grain approximately is one quarter of that parallel to it (1). The constitutive model widely admitted assume a lineal-elastic behaviour under tension up to failure, and elastic-plastic under compression (2,4). Composite materials applied as a reinforcement of timber structural element are being currently studied as an alternative and optimum option (3,4,5).

2. Materials and testing method – An experimental work has been performed, consisting of eighteen prismatic pieces of scots pine timber. The mean dimensions of the specimens were 158 by 158mm of cross section, and 300mm length. Two different fabrics were used to reinforce the pieces: 300 g/m2 carbon fibre and 280g/m2 basalt fibre (Table 1). Epoxi resin was used both to make up the composite material and adhere to the timber. Specimens were tested under simple compression obtaining load and displacement values (Table 2).

Type of fiber	Carbon	Basalt	Basalt
Grammage (g/m^2)	300	280	600
Thickness (mm)	0.111	0.103	0.206
Tensile strength (N/mm^2)	3,400	2,100	2,100
Modulus of elasticity(kN/mm^2)	230	105	105

Table 1. Fabrics characteristics

Reinforcement	Fmax (kN)	ΔFmax(%)	δ (mm)
SR C	591,73	-	3,02
FB280	1.363,93	130,50	2,67
FB600	1.377,08	132,72	2,58
FC300	1.151,72	94,64	3,33

Table 2. Maximum loads and displacement values obtained in the compression tests

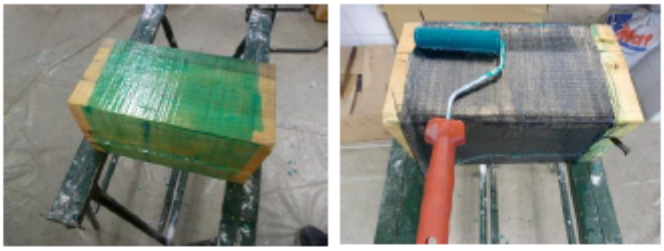

Fig. 2. Reinforcement process. First and termination layer of resin matrix before and after applying the fabric

3. Results – The higher load is reached by the pieces reinforced with basalt-fabric reinforcements, both FB280 and FB600. As it is shown in the table 2, the maximum load increase of the samples reinforced with basalt fabric is approximately 130% in both 280 and 600g/m2 grammage. The increase of the maximum load of those reinforced with carbon fabrics is approximately 40% lower. Regarding the displacements, carbon-fabric reinforcement performed bigger displacements than those of basalt-fabric. Figure 3 shows the load-displacement diagrams, where FB280 and FB600 have higher rigidity than FC300.

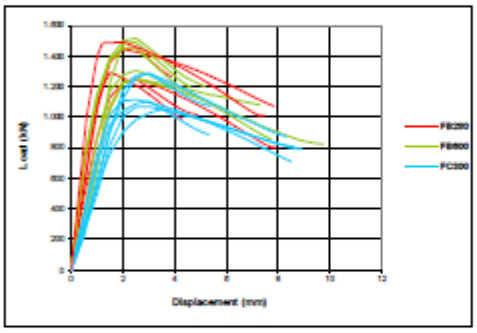

Fig.3. Load-displacement diagrams

4. Conclusions – Carbon and basalt composites increase the maximum load significantly as reinforcement of timber pieces under compression.
Comparing the increase of the maximum load of reinforced specimens to those non-reinforced, basalt reinforcements increase is 40% higher than carbon.
Basalt FRP obtained better results than carbon FRP, regarding both strength and stiffness.

References

[1] Argüelles R.; Arriaga, F.; Martínez, J. (1996). "Estructuras de madera. Diseño y cálculo".
[2] Bazan I.M.M.(1980). "Ultimate bending strength of timber beams". Tesis Doctoral, Nova Scotia Technical Colledge, Halifax, Nova Scotia, Canadá.
[4] Conners T. E. (1989). "Segmented models for stress-strain diagrams". Wood Science and Technology, 23, 65-73.
[3] CNR-DT (2007). Guidelines for the design and construction of externally bonded FRP systems for strengthening existing structures. National Research Council, Roma.
[[5] Gezer H.; Aydemir B. (2010). "The effect of the wrapped carbon fibre reinforced polymer material on fir and pine Word". Materials and Design, 31, 3564-3567.
[6] Ma, J. X.; Hu, P.; Jiang, X. M.; Hu, M. (2005). "Experimental research on axial compressive behaviours for timber column strengthened with CFRP". Industrial Construction, 35, 40-44.